WHAT IS CLAIMED IS:

1. A semiconductor device equipped with a fuel cell, the semiconductor device comprising a fuel cell and a semiconductor element,

wherein

the fuel cell includes an anode separator in which a flow channel for fuel is formed, a cathode separator in which a flow channel for oxidizer is formed, and a membrane electrode assembly interposed between the anode separator and the cathode separator,

the semiconductor element is formed on a principal surface of one separator selected from the anode separator and the cathode separator, and

the semiconductor element and the selected separator are connected electrically.

2. The semiconductor device according to claim 1,

wherein two of the semiconductor elements are included, the semiconductor elements being a first semiconductor element formed on a principal surface of the anode separator, and a second semiconductor element formed on a principal surface of the cathode separator.

3. The semiconductor device according to claim 1,

wherein the selected separator is formed with a semiconductor substrate.

4. The semiconductor device according to claim 3,

wherein the semiconductor substrate is made of crystalline silicon.

5. The semiconductor device according to claim 3,

wherein the semiconductor substrate is made of a compound semiconductor containing an element of the group IIIb and an element of the group Vb.

6. The semiconductor device according to claim 3,

wherein the semiconductor substrate is made of a compound semiconductor containing an element of the group IIb and an element of the group VIb.

7. The semiconductor device according to claim 3,

wherein the anode separator is formed with a N-type semiconductor substrate and the cathode separator is formed with a P-type semiconductor substrate.

8. The semiconductor device according to claim 3,

wherein the fuel cell further includes a contact layer arranged between the selected separator and the membrane electrode assembly so as to reduce a contact resistance between the selected separator and the membrane electrode assembly.

9. The semiconductor device according to claim 1,

wherein the fuel cell further includes an insulation layer formed between the semiconductor element and the selected separator.

10. The semiconductor device according to claim 9,

wherein the semiconductor element is connected electrically with the selected separator via an electrode formed in the insulation layer.

11. The semiconductor device according to claim 9,

wherein the insulation layer is made of SiO_2.

12. The semiconductor device according to claim 9,

wherein the insulation layer has a specific resistance of not less than 10^5 Ω·cm.

13. The semiconductor device according to claim 9,

wherein the insulation layer has a thickness in a range of 10 nm to 1 μm.

14. The semiconductor device according to claim 9,

wherein the selected separator is made of a metal.

15. The semiconductor device according to claim 14,

wherein the insulation layer is a metal oxide film.

16. The semiconductor device according to claim 1,

wherein

the semiconductor element includes a first electrode and a second electrode,

the first electrode is connected electrically with the anode separator, and

the second electrode is connected electrically with the cathode separator.

17. The semiconductor device according to claim 1,

wherein

the semiconductor element is a N-channel MOS transistor,

a source electrode and a substrate electrode of the N-channel MOS transistor are connected electrically with the anode separator, and

a drain electrode and a gate electrode of the N-channel MOS transistor are connected electrically with the cathode separator.

18. The semiconductor device according to claim 1,

wherein

the semiconductor element is a P-channel MOS transistor,

a source electrode and a gate electrode of the P-channel MOS transistor are connected electrically with the anode separator, and

a drain electrode and a substrate electrode of the P-channel MOS transistor are connected electrically with the cathode separator.

19. The semiconductor device according to claim 1,

wherein the fuel cell is formed by stacking a plurality of cells, each cell including the anode separator, the cathode separator, and the membrane electrode assembly.

20. A method for producing a semiconductor device equipped with a fuel cell having a structure in which a membrane electrode assembly is interposed between a pair of separators, the method comprising the steps of:

(i) forming a semiconductor element on one surface of a semiconductor substrate;

(ii) forming a flow channel through which either fuel or oxidizer is to flow on a surface of the semiconductor substrate that is opposite to the surface on which the semiconductor element is formed; and

(iii) laminating the membrane electrode assembly on the semiconductor substrate so that the surface of the semiconductor substrate with the flow channel thereon is in contact with the membrane electrode assembly, wherein the semiconductor substrate serves as one separator selected from the pair of separators.

21. The method according to claim 20,

wherein the semiconductor substrate includes an insulation layer between the surface with the semiconductor element thereon and the surface with the flow channel thereon.

22. The method according to claim 21,

wherein the step (i) includes a sub-step of:

(a) forming the semiconductor element on the insulation layer in a manner such that the semiconductor element and the semiconductor substrate are connected electrically with each other via an electrode formed in the insulation layer.

23. A method for producing a semiconductor device equipped with a fuel cell having a structure in which a membrane electrode assembly is interposed between a pair of separators, the method comprising the steps of:

(I) forming a flow channel through which either fuel or oxidizer is to flow on a surface of the semiconductor substrate;

(II) forming a semiconductor element on a surface of the semiconductor substrate that is opposite to the surface on which the flow channel is formed; and

(III) laminating the membrane electrode assembly on the semiconductor substrate so that the surface of the semiconductor substrate with the flow channel thereon is in contact with the membrane electrode assembly, wherein the semiconductor substrate serves as one separator selected from the pair of separators.

24. The method according to claim 23,

wherein the semiconductor substrate includes an insulation layer between the surface with the flow channel thereon and the surface with the semiconductor element thereon.

25. The method according to claim 24,

wherein the step (II) includes a sub-step of:

(A) forming the semiconductor element on the insulation layer in a manner such that the semiconductor element and the semiconductor substrate are connected electrically with each other via an electrode formed in the insulation layer.